

REMARKS

The Applicant would like to thank the Examiner for carefully reviewing the specification and claims. The Applicant particularly appreciates that the Examiner properly considered the merits of the claims despite a number of informalities in them. The foregoing amendments and the following remarks are intended to be responsive to each of the grounds of rejection and objection cited in the Office Action mailed April 28, 2005.

1. Amendments to the Drawings

Figures 1 and 2 were objected to for various informalities. The Applicant submits herewith formal drawing replacement sheets for the Examiner's approval. The Applicant believes that the replacement sheets are responsive to all of the drawing objections raised in the Office Action.

2. Objections to the Claims

Claims 7 and 17 have been amended as suggested by the Examiner to reflect the proper combination of attributes determined by using the method or computer program according to the invention.

Claims 12-15, and 17-20 have been amended to reflect dependence from the proper base claim. The Applicant believes the amendments are responsive to the formalities noted in the Office Action.

3. Claim Rejections -35 U.S.C. § 102(b)

Claims 1, 5, 6 and 11 were rejected as anticipated by Kelly et al. (U.S. Patent No. 5,136,552- "Kelly"). The Applicant respectfully traverses the rejection for the reasons which follow.

Claim 1 recites generally a method for identifying zones anomalously absorptive of seismic energy. The method includes joint time-frequency decomposition of seismic data traces. The decomposed traces are low frequency bandpass filtered to determine a general trend of mean frequency and bandwidth of the seismic traces. The decomposed traces are then high frequency bandpass filtered to determine local variations in the mean frequency and bandwidth of the

seismic traces. Anomalous absorption zones are determined where there is difference between the general trend and the local variations.

Generally, Kelly discloses a method of geophysical exploration that includes bandpass filtering a set of seismic data with a plurality of bandpass filters. The set of seismic data comprises normal moveout corrected and stacked seismic signals. Each of the bandpass filters is adapted to pass a selected pass band of frequency. Changes in amplitude as a function of varying passband frequencies are used to identify reflection events in the set of seismic data that are associated with gradational changes in the earth's elastic impedance. Gradational changes may be associated with changes of formation pore fluid pressure greater than hydrostatic.

Kelly does not disclose, in particular, joint time-frequency decomposition of seismic traces, as recited in claim 1. Joint time-frequency decomposition, as is meant with respect to the Applicant's invention, can be described as separating each seismic trace (or groups of such traces) into relative amplitudes or energy levels of the seismic energy at particular frequencies, or within defined frequency ranges. The frequency decomposition is performed to provide output at distinct times along part of or all of the seismic trace(s). Time-frequency decomposition provides an output that can be presented in trace plots, such as shown in Figure 2, wherein each input seismic data trace can be decomposed into a plurality of decomposed traces. Each such decomposed trace represents the amplitude of or the energy content of the original seismic trace at a plurality of defined frequencies or within defined ranges of frequencies, with respect to time (which increases in a downward direction just as the original, input seismic traces). The example in Figure 2 shows an input seismic trace at 30 and the trace envelope, generally defined as the instantaneous trace energy, at 32. It is important to understand what is shown in Figure 2, because it goes to the core of the distinction between the disclosure of the art of record and the Applicant's claimed process. In the Applicant's claimed process, the joint time-frequency decomposition can be computed instant by instant, meaning that for every individual input trace amplitude value (a trace being a representation of acoustic or seismic amplitude with respect to time) a corresponding value for amplitude of each component frequency or each frequency passband can be computed. The joint time-frequency decomposition thus computes one type of seismic characteristics known as "instantaneous

attributes.” Instantaneous attributes are specific characteristics of a seismic trace that can be computed at any instant in time within a seismic trace.

Next, in the Applicant’s invention, the decomposed traces (as contrasted with the traces themselves) are analyzed to find their average frequency and bandwidth with respect to time. The average frequency and bandwidth are low-frequency bandpass filtered to establish the general trend of average frequency and bandwidth with respect to time. The low pass (low frequency bandpass) filtering thus provides an indication of how the acoustic energy absorption characteristics of the layers of the Earth change with respect to two-way seismic travel time (which roughly corresponds to depth). Ordinarily, absent the presence of anomalously absorptive formations, such as those bearing natural gas, the trend in average frequency and bandwidth with respect to time is monotonic, as shown in Figure 2. The average frequency and bandwidth of the traces are then high-pass filtered to enable identification of anomalously absorptive zones. Anomalously absorptive zones show variations in the average frequency and bandwidth from the general trend of average frequency and bandwidth with respect to time (determined from the low pass filtering).

Because the previously described joint time-frequency decomposition is a necessary input to determining the average frequency and bandwidth with respect to time, Kelly cannot show or suggest determining an instantaneous average frequency and bandwidth of decomposed seismic traces with respect to time. Moreover, Kelly does not show or suggest determining an average trend of such parameters. Bandpass filtering as shown in Kelly is to the original traces or stacked traces. Such filtering removes some frequency components of the traces, but does not establish any information about the average frequency and bandwidth of the traces with respect to time. Finally, Kelly does not show or suggest identification of anomalously absorptive zones by identification of local variations of such parameters from the trend. Accordingly, Kelly cannot anticipate claim 1.

Claims 1, 5, 8, 11, 15 and 18 were also rejected as anticipated by Calvert et al. (U.S. Patent Application Publication No. 2002/0042702 – “Calvert”). Applicant respectfully traverses this rejection for the reasons which follow.

Calvert does describe applying passand filters to various data, and combining the passband-filtered data to construct a complete earth model. It is important to understand that the

disclosure in Calvert relates only to passband filtering various rock property data, and in no way includes any joint time-frequency decomposition operation on seismic data traces, as recited in the Applicant's claims. The relevant portion of the description in Calvert begins with paragraph [0040] and is reproduced below.

[0040] With reference to FIG. 3, the geologic modeling method of the present invention involves integrating different resolution-scale data types by constructing one or more initial frequency-passband models, combining these initial models to form an initial complete geologic model, and then optimizing one or more of these initial models to form the final complete geologic model. This is done using data which includes interpreted geologic architecture 102 that defines the limits of the model, regions within the model and stratigraphic correlations within the model, and desired criteria 110 that define the distributions and relations of rock properties in the complete geologic model and/or one or more of the individual frequency-passband models. Optionally, and desirably, several data types may be used in constructing the initial frequency passband models, including rock property data 104 derived from core and well logs, seismic data 106 derived from seismic surveys, and other data types 108 that could be used to indicate distributions of rock properties within the model.

[0041] The initial frequency-passband models 111 are generated by assigning at least one rock property value to all model blocks within each model. The initial complete geologic model, in either seismic time or depth, is constructed by mathematically combining all frequency-passband models. The rock properties assigned to blocks may include, but are not limited to, porosity, shale volume, net sand percent, net pore volume, hydrocarbon saturation, hydrocarbon pore volume, impedance or permeability. This step may be done in any convenient way, though the frequency content of the rock properties assigned to each initial frequency-passband model should be consistent with the frequency band represented by that model and results may be improved if the initial models are consistent with desired criteria.

[0042] If each initial frequency-passband model represents a frequency band that does not overlap with the frequency band of any other initial frequency-

passband model, then the initial complete geologic model can be constructed by summing all frequency-passband models. If, however, multiple initial frequency-passband models have overlapping frequency bands, special consideration must be given to correctly combining them together to obtain the initial complete geologic model. One method of combining such models is to perform the combination as a weighted-summation in the frequency domain. Weights are specified as a function of frequency for each initial frequency-passband model. This can be simplified somewhat by assigning a global weight such that all frequencies within the passband of a given initial model have the same assigned weight (global value) and have zero weight outside this band

[emphasis added] To summarize, the disclosure in Calvert is intended to enable combination of data having different vertical resolutions. There is nothing in Calvert which relates to determining, with respect to time, the average frequency and bandwidth of seismic data at particular frequencies or within selected passbands. Accordingly, Calvert cannot anticipate claim 1.

4. Claim Rejections – 35 U.S.C. § 103(a)

Claims 1, 5, 6, 8, 11, 15, 16 and 18 were also rejected as obvious over He et al. (U.S. Patent No. 5,798,982 – “He”) in view of either Lance or Thurston. Applicant respectfully traverses this rejection.

He is asserted as showing a method to detect anomalously absorptive zones from seismic data at col. 2, lines 21-40. Applicant respectfully disagrees. The method disclosed in He is for “inverting seismic waveforms into [acoustic] impedance models of a subsurface region and an improved method that utilizes 3-D and 4-D time-dependent changes in acoustic impedances inverted from seismic waveforms to make quantitative estimates of the petrophysical changes in hydrocarbon reservoirs...” He, col. 2, lines 21-28. Applicant admits that He uses the phrase “time-dependent changes.” However, that term as used in He means changes in the acoustic impedance model between seismic surveys made over the same subsurface region, but at different times. Such meaning is consistent with the definition of 4-D seismic surveying, which means precisely the taking of a seismic survey over the same subsurface region at different times in order to infer the movement of fluids in the Earth’s subsurface by changes in seismic

properties. Rather than on the order of seconds, as is the case for elapsed time from actuation of a seismic source in seismic trace recording, “different times” as used in 4-D seismic surveying generally means time frames on the order of weeks, months or even years. He does not disclose determining any changes of seismic trace properties with respect to time within a single seismic trace, group of traces take from a single seismic survey. As used in the Applicant’s invention, “time” means the elapsed time from actuation of a seismic energy source to detection of reflected seismic energy from subsurface acoustic reflectors. The term “time” as used in the He disclosure means something entirely different than does the term as used in the Applicant’s claims. Therefore, to the extent He discloses determining any parameters that change with time, He does not mean that changes in such parameters are determined within the recording time of a single seismic trace of group of such traces.

He was asserted as showing joint time-frequency decomposition of seismic data traces, as recited in claim 1. Applicant respectfully disagrees. The first cited portion of He, col. 2, line 48 to col. 3, line 30 deals with the overall methodology of He’s inversion scheme. The inversions scheme in He includes using a forward model to construct a seismic trace from an acoustic impedance model. Inversion procedures are used to iteratively adjust the impedance model until the forward modeled seismic trace substantially equals actual measured seismic traces. The acoustic impedance model is initially constrained using a low frequency impedance model made from well log data. Aside from the fact that no acoustic impedance model is made or used in the Applicant’s claimed invention, the Applicant’s invention also makes no direct use of well log data. Applicant respectfully refers the Examiner to the explanation of joint time-frequency decomposition above with reference to Calver and Kelly. Nothing in the foregoing cited portion of He relates to decomposing seismic traces to obtain frequency content at various times along the traces (as contrasted with the use of the word “time” in 4-D seismic).

A second cited portion of He, col. 4, lines 45-62 is asserted as showing joint time-frequency decomposition of seismic traces, because a wavelet has frequency and time components. Applicant respectfully disagrees with such conclusion. First, any seismic data includes time and frequency components, but identification of such components is not *per se* joint time-frequency decomposition. The wavelet function referred to in He is a dynamically extracted seismic energy source function that is intended to normalize the effects of differences

in source wavelet between successive seismic surveys, so that each survey in a 4-D survey set can be matched in “spatial extent, orientation and resolution.” He, col. 4, line 51. What this portion of He explains is that the inversion and modeling technique disclosed in He is intended to provide results which show “true amplitude differences [between successive seismic surveys] when inverting to derive acoustic impedance.” The significance of determining a wavelet function is that a forward model of formation seismic response can be made by convolving a seismic wavelet with a reflection coefficient series, or acoustic impedance series. A seismic wavelet is most typically embodied as a set of seismic amplitudes over a fixed length time window. While a wavelet certainly contains time and frequency information, no decomposition is shown or fairly suggested by He which presents the content of a wavelet in 2-dimensional form, as in Applicant’s Figure 2, wherein an amplitude or energy content within a plurality of frequencies or passbands, with respect to instant in time. Nowhere in this cited portion of He, or anywhere else in the document for that matter, does He disclose decomposing seismic traces to determine amplitude or energy of various frequency components with respect to two way travel time, as shown in Applicant’s Figure 2. Further, He does not in any way described determining average frequency and bandwidth of seismic traces with respect to actuation time of the seismic source (clarifying Applicant’s clear use of the term “time”). Applicant again refers to the explanation of joint time-frequency decomposition above with reference to Kelly and Calvert to show no such process is disclosed in He.

He is also asserted as determining a general trend from acoustic impedance data. He does not, however, determine a general trend of average frequency and bandwidth of seismic traces that have been jointly time-frequency decomposed. Irrespective of the common use of the term “trend”, Applicant here makes an important distinction between the uses of the term “trend” in the claimed invention and in He. In He, the trend is an average change in acoustic impedance, which is an inferred property of Earth formations. The trend is used in He to constrain models of acoustic impedance for the inversion process. In the Applicant’s invention, the trend is a property of the seismic data themselves. No inference is required as input to determine the trend. In fact, the He disclosure contemplates some a priori knowledge of the existence of, extent of and properties of a subsurface reservoir, such as from well log data. Applicant’s invention requires no such knowledge; inferences about the existence of a reservoir are made only from the

seismic data. Accordingly, He fails to disclose so many elements of the Applicant's invention of claim 1, that no combination of He with any of the art of record provides the invention of claim 1.

The Applicant thus believes that claim 1 is patentable over the art of record. Claims 2-10 ultimately depend from claim 1 and are patentable for at least the same reasons advanced with respect to claim 1.

Claim 11 recites a computer program which causes a computer to perform the method recited in claim 1. Claim 11 is therefore patentable over the art of record for at least the same reasons advanced with respect to claim 1. Claims 12-20 ultimately depend from claim 11 and are patentable for at least the same reasons advanced with respect to claim 1.

The Applicant believes that this Reply is fully responsive to each and every ground of rejection and objection cited in the Office Action of April 26, 2005, and respectfully requests early favorable action on this application.

Respectfully submitted,

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